FLOWERING PHENOLOGY OF THE MANGROVES FROM THE WEST COAST OF MAHARASHTRA[1]

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INTRODUCTION

Mangrove ecosystems are under heavy pressure as a result of increase in human activity. The area under mangroves is getting reduced, and some important species are becoming extinct. Therefore, it is necessary to have a permanent record of its phenology. This type of study is almost nil along the coast of Maharashtra. The study of phenology is essential, as it has many applications such as in regeneration, afforestation, plant management, honey analysis, floral biology and the estimation of reproductivity. This study was based in Ratnagiri district, from where sites were selected on the basis of earlier ecological studies.

MATERIAL AND METHODS

Three sites were selected for this study: Bandhkhind, Ganapatipule and Bhatye. At Bandhkhind there were some pure stands (populations) of *Sonneratia alba* and *Rhizophora mucronata* At Ganapatipule an important species, *Bruguiera gymnorrhiza*, was found. At Bhatye *R. apiculata, Avicennia marina* and *Kandelia candel* occurred. In all, twelve species of mangroves were studied. They are: *R. mucronata*, Lamk.; *R. apiculata* Blum.; *B. gymnorrhiza* Lamk.; *K. candel* (L.) Druce; *Ceriops tagal* (Perr); *Aegiceras corniculatum* (Linn.) Blanco; *Avicennia officinalis*, Linn.; *A. marina* var. *acutissima* Stapf and Moldenke; *Sonneratia alba* Sm.; *Excoecaria agallocha* Linn.; *Lumnitzera racemosa* (Willd.); *Acanthus ilicifolius* Linn. Phenophases were observed every fortnight for each species and monthly variations were recorded. Phenophases like initiation, budding, blooming, fruiting and seedling development were noted. Continuous observations from April 1983 to May 1985 were made to collect data.

RESULTS AND DISCUSSION

In most of the mangrove species flowering commences in the summer months (Jones 1971, Graham *et al.* 1975, Byrnes *et al.* 1977 and Saenger 1982). It was noted during our field observations that *R. mucronata*, flower primordia develop on the young plant when it is about four years old. Gill and Tomlinson (1969) reported a similar period. However, they noted flowering in *R. mangle* when it was one metre in height. Nevertheless, data on floral initiation in mangroves is very scanty. In the present study initiation of flowering was recorded during the month of December for *R. mucronata.* It was maximum in January and continued in February. There was a slow increase in budding in the beginning, followed by a sharp increase from April to May. *R. mucronata* flowers heavily during September to November but blooming actually starts in July and then continues throughout the year. Mature propagules were found hanging on the mother plant in May-June in maximum numbers. The whole cycle continues throughout the year.

The phenology of *R. apiculata* is interesting. Initiation is observed in the beginning of May. It continues for quite a long time, up to August and even later. Budding stage is found very late, and is recorded up to September. After such a slow initial development of reproductive parts there is a steep increase and maximum blooming was noticed in October. All the phases in *R. apiculata* overlap and throughout the year one or the other stage is observed. The fruit, once formed, matures within 2–3 months and then the vivipary starts

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appearing. By the end of August all mature propagules are shed. According to Christensen and Wium-Anderson (1977) the period required from primordia formation to propagule maturation in *R. apiculata* is three years. In the present study this has not been observed. If the propagular development is a long process, the presence of ''germinated fruit'' on the mother plant throughout the year is essential.

In *Bruguiera gymnorrhiza* initiation is recorded at the beginning of January and continues up to April. There is a slow increase in flowering initially, followed by a sharp increase from mid–January to February. There is a sharp decline in flowering which almost ceases in the beginning of February and shows a sudden increase to a maximum in April–May, followed by a steady decline. In December different developmental stages are found. The propagules are recorded from June to August. The observation that the flowering in *B. gymnoryhiza* commences in the summer months supports earlier reports (Jones 1971, Graham *et al.* 1975, Specht *et al.* 1977).

Kandelia candel flowers and fruits simultaneously, and mature propagules can be seen when the plant starts flowering during the following year. Initiation is recorded from December to February, and is also seen in August–September as a second phase. Flowering peak is recorded during February–March. Thereafter there is a sharp abatement, with decreasing yields of reproductive material recorded until the end of August. In *K. candel* the total development period calculated according to our observations is nearly 10–12 months. The development period is similar to that recorded by Nishihira and Urasaki (1976); i.e. 12 months from flower buds to mature propagule. The total developmental time from bud to seedling stage is about six months as reported by Wafar (1985). However, in the present investigation the period observed is much longer.

It is interesting to note the floral initiation in two phases. When it starts in August–September, the propagule matures within 10 months. However, when it takes place in December–February, the time taken for development of the mature propagule seems to be greater. It was not possible to make any observation with this phase of development. Looking at the other members of Rhizophoraceae which take almost a year for development of the mature propagule, it appears that *K. candel* may not produce a fully developed propagule within six months (December–June). Further investigation is in progress.

In *Ceriops tagal*, floral initiation was recorded during April, and continued up to August. Simultaneously the next phase, budding, starts. Bud formation was observed from May to September. Blooming is found throughout the year. The maximum flowering was found in September and October. From April to June, heavy fruiting was observed. The mature propagules of *Ceriops* are recorded from June to August. The time required for the development from floral bud to mature propagule is more than a year. This is similar to the observations of Wium- Andersen, and Christensen (1978) who found that the development from floral bud to fruit takes about 12–18 months. It is evident from the data that in *Ceriops* also budding, blooming and fruiting occur year round and that phases, one after the other, continue the cycle. It should be noted here that the propagules shed from June to August are developed from the fruits of the preceeding year.

Sonneratia alba shows floral initiation as early as December, continuing up to February. Again, initiation is recorded during June–July (early monsoon). Budding is recorded from January onwards till the end of August. Flowering appears in January and continues up to October, with a first peak in March and a second peak in June. It is evident from the data that in *Sonneratia* also all phenophases overlap and continue throughout the year.

The floral buds in *Sonneratia*, after their appearance, open into flower within 1–1.5 months. Flower to fruit development takes about 4 to 6 months, and the maturation of fruit takes nearly two months. Thus the total period of mature seed formation in *Sonneratia* is about 12 months. Only

a few fruits are observed on the plant, and out of all the flowers formed only a few develop into fruits.

Avicennia officinalis and *Avicennia marina* both showed different patterns in their phases. In *A. officinalis* initiation is recorded from early January up to the end of February. The phenophase of *A. officinalis* reveals that the flowering period is short when compared to other genera. Budding appears during February and extends up to May. Flowering begins in March and extends up to July. The maximum number of flowers occur during April–May and fruits from June to early August. The developed seedling inside the mature fruit is released and falls to the ground from June to early August, when it starts establishing itself. From September to December there is a complete vegetative stage of the plant. No other phenophases were observed during this period at any of the sites under study.

In *A. marina* floral initiation is observed from January to April and flowering begins in early March, reaching a maximum in May. Fruit initiation starts in early April and extends up to September, i.e. flowering and fruiting come to an end towards late September. Seedlings are found on the soil from August to early October. In *A. marina* community, litter yields of leaves and reproductive material an showed increase from mid March to the end of April in South Africa (Steinke and Charles 1984). Similar patterns of flowering and fruiting phenophases are recorded in the present study.

Excoecaria agallocha is dioecious, bears flowers in catkins, possesses 2–celled pollen grains, and is presumably wind pollinated. No detailed information is available on the phenology of mangroves. Flowering was recorded in *Excoecaria* in a 2 year old plant. During the vegetative stage it is difficult to distinguish between male and female plants. Floral initiation in male plants of *Excoecaria* occurs during March and in female plants in the month of November, then again initiation stage is recorded during April and May in both sexes simultaneously. Buds of female flowers and young male catkins start appearing during April–May and real blooming occurs during May to June. Fruiting stage starts from July, and continues up to end August. In September, different seed developing stages are seen. Seeds start maturing from September. During September to October very young seedlings were observed on the soil.

The floral initiation in *Lumnitzera racemosa* was observed between November and February. Budding begins in January and culminates with a decline in May, and is again seen between June and September. Flowering occurs from March to April and extends up to October. Simultaneously fruiting is also recorded during the months of February to December. Maximum fruiting is recorded during July and August. The seeds of different stages such as very young, as also mature, are seen during September to December. All phenophases, except initiation, are seen in July and August.

Aegiceras corniculatum is a much branched shrub, which inhabits areas that are inundated by normal high tides. Flowers of *A. corniculatum* are scented and are an important source of honey. In this species flowering was first observed at a height of 0.27 m by Steinke and Ward (1973).

Initiation starts in early September and ends in early November. Again in January and February initiation is recorded in a few plants. Budding is seen during November to February. *Aegiceras* starts blooming in early December and ends in early April. Fruiting stages are between late December to July. Mature fruits (cryptoviviparous) are recorded from May to early August. In general, the reproductive phase in *Aegiceras* is restricted to a period of a few months. Analysis of the data reveals that flowering and fruiting comes to an end towards late summer. The mature fruit contains a well developed seedling inside (cryptovivipary). From late June to early August these fruits are shed. They can be called as propagules.

Acanthus ilicifolius is a small shrub that grows well in open mangrove areas. In *Acanthus* two distinct phases are observed, the vegetative and the reproductive. The vegetative phase takes three

months, September to November. Then there is transition from vegetative to reproductive growth. Initiation is restricted to December and January only. Bud formation is found from January to March. Maximum flowering is recorded towards the end of March and April. Not all flowers open at the same time. Therefore, the 'Blooming' period is recorded from January to May. Fruiting is from April to July. During June–July different fruit development stages are observed. Fruits with mature seeds are found from June to July end. The seeds are released by dehiscence of fruit on the plant; after this beds of seedlings are found all over the area. No seed can be seen on the plant after the first week of August. Jagtap (1985) has reported flowering in *Acanthus* during August. In the investigation, in spite of several attempts no seeds were observed during late August. Flowering was found to be completed still earlier.

Phenological rhythms such as flowering or fruiting vary from one species to another in a given locality (Blasco 1984). Some species of *Avicennia* flower at the end of the dry season (March–April–May), whereas the flowers of *Bruguiera cylindrica* are collected in September–October (end of the rainy season) and those of *Lumnitzera* mainly during November to January (winter).

The twelve mangrove species analysed in the present investigation have revealed different patterns of phenophases. Different species of mangroves have adapted differently. In Rhizophoraceae members in all stages of development can be found throughout the year. Gill and Tomlinson (1969) have reported *R. mangle* as flowering throughout the year.

Uptil now little information is available on the initiation of flowering. The present data gives an idea about the initiation phase among twelve mangroves, which is important for further ecological studies. The occurrence of propagules in mangroves in Ratnagiri district is maximum in summer. In some species the time from flower to mature propagule varies greatly. Since leaf production in *Rhizophora* is also seasonal, with a maximum during summer (Christensen and Wium-Anderson 1977; Gill and Tomlinson 1971), it seems that fruiting is limited to the period most favourable for growth. In a region with alternating seasons, the life cycle of plants is synchronised to the long term changes in the weather (Larcher 1975). Flowering period in *Halophila* occurs over ranges of temperature and day lengths but is reported to show strong correlation with the nutrient conditions of water (McMillan 1980). In *Cymodocea* flowering is reported to be strongly influenced by high temperature (31°/27°C Day/Night).

Hence, flowering in mangroves is expected to be controlled by an interaction of temperatures and photoperiod conditions. There is response to longitudinal distribution by mangrove species with respect to flowering. It is found in the present investigation that flowering and fruiting in *Aegiceras corniculatum*, which is distributed only over a few months, is later by about a week at Ganapatipule than at Bandhkhind. This may be attributed to the difference in longitude of the two places–Ratnagiri (17°0' N, 73°2' E) and Ganapatipule (17°9' N, 73°2' E). In all the mangrove species along the Goa coast, extensive flowering was noticed during March to June and extensive fruiting during April to July. Flowering and fruiting was observed to be generally poor or absent during September to January. An extensive flowering during March to June may be attributed to higher temperatures and longer duration of light (photoperiod). Thus the phenological characteristics of mangrove species are related to different environmental factors.

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